What is claimed is:

1. A method for producing a semiconductor device, comprising the steps of:

forming an interconnection groove in an insulation film formed on a substrate;

stacking a copper film having unevenness on its surface corresponding to the step difference of the interconnection groove on the entire surface of the insulation film so as to bury the interconnection groove;

interposing an electrolytic solution comprising a chelating agent between a cathode member and the copper film, applying a voltage between the cathode member functioning as a cathode and the copper film functioning as an anode to oxidize the surface of the copper film and form a chelate film of oxidized copper;

selectively removing a projecting portion of the chelate film corresponding to unevenness of the copper film to expose the copper film of the projecting portion at its surface; and

repeating the above chelate film forming step and the chelate film removing step until the projecting portion of the copper film is flattened.

2. A method for producing a semiconductor device as set forth in claim 1, further comprising a step, after flattening the projecting portion of the copper film, of

removing the chelate film formed on the surface of the copper film until the copper film stacked outside said interconnection groove is removed.

3. A method for producing a semiconductor device as set forth in claim 2, further comprising a step of forming a barrier film comprising of a conductive material for preventing diffusion of said copper film to said insulation film so as to cover the insulation film and the inside of said groove after said forming an interconnection groove and before stacking the copper film.

4. A method for producing a semiconductor device as set forth in claim 1, wherein in said step of applying a voltage by using said cathode member as a cathode, a voltage is applied by using a conductive polishing tool for removing a projecting portion of said chelate film, as a cathode.

5. A method for producing a semiconductor device as set forth in claim 4, wherein an anode member contacting or near said copper film is made to be the anode and the copper film is made to be the anode through said electrolytic solution in said step of applying a voltage using said copper film as the anode.

6. A method for producing a semiconductor device as set forth in claim 1, wherein in said step of applying

a voltage by using said cathode member as a cathode, a voltage is applied by using a conductive electrode plate arranged parallel with said copper film as a cathode.

7. A method for producing a semiconductor device as set forth in claim 3, wherein in said step of applying a voltage by using said cathode member, a voltage is applied using as a cathode a conductive electrode plate arranged parallel with said copper film as a cathode.

8. A method for producing a semiconductor device as set forth in claim 1, wherein in said step of removing a chelate film, said chelate film is removed by wiping or mechanical polishing.

9. A method for producing a semiconductor device as set forth in claim 1, wherein in said step of removing a chelate film, said chelate film is removed by chemical mechanical polishing using a chemical polishing agent having a polishing abrasive.

10. A method for producing a semiconductor device as set forth in claim 3, wherein in said step of removing the chelate film, said chelate film is removed by wiping or mechanical polishing.

11. A method for producing a semiconductor device as set forth in claim 10, wherein in said step of removing the chelate film, said chelate film is removed by relatively moving a polishing tool on the surface of

the chelate film.

12. A method for producing a semiconductor device as set forth in claim 10, wherein in said step of removing the chelate film, said chelate film is removed by applying vibration to said substrate.

13. A method for producing a semiconductor device as set forth in claim 1, wherein in said step of removing the chelate film, said chelate film is removed by flushing said electrolytic solution.

14. A method for producing a semiconductor device as set forth in claim 1, wherein in said chelate film forming step and chelate film removing step, a current flowing through said cathode member and said copper film is monitored, and the progress of the polishing of the copper film is controlled in response to the magnitude of the current.

15. A method for producing a semiconductor device as set forth in claim 3, wherein in said chelate film forming step and chelate film removing step, a current flowing through said cathode member and said copper film is monitored, and the progress of the polishing of the copper film is controlled in response to the magnitude of the current.

16. A method for producing a semiconductor device as set forth in claim 3, wherein Ta, Ti, W, Co, TaN, TiN,

WN, CoW, or CoWP is used for the material forming said barrier film in said step of forming the barrier film.

17. A method for producing a semiconductor device as set forth in claim 1, wherein a chelating agent forming a chelate film having a higher electrical resistance and a lower mechanical strength than said copper film is used as said chelating agent.

18. A method for producing a semiconductor device as set forth in claim 3, wherein a chelating agent forming a chelate film having a higher electrical resistance and a lower mechanical strength than said copper film is used as said chelating agent.

19. A method for producing a semiconductor device as set forth in claim 1, wherein quinaldine acid, glycin, citric acid, oxalic acid, or propionic acid is used as said chelating agent.

20. A method for producing a semiconductor device as set forth in claim 3, wherein quinaldine acid, glycin, citric acid, oxalic acid, or propionic acid is used as said chelating agent.

21. A method for producing a semiconductor device as set forth in claim 1, wherein,

in said step of forming the interconnection groove, a contact hole is formed for connecting an impurity diffusion region or interconnection formed at a

layer below said insulation film with an interconnection formed in the interconnection groove along with the formation of an interconnection groove, and

in said step of stacking the copper film, an interconnection groove is buried together with a contact hole with copper.

22. A method for producing a semiconductor device as set forth in claim 3, wherein

in said step of forming the interconnection groove, a contact hole is formed for connecting an impurity diffusion region or interconnection formed at a layer below said insulation film with an interconnection formed in the interconnection groove along with the formation of an interconnection groove, and

in said step of stacking the copper film, an interconnection groove is buried together with a contact hole with copper.

23. A polishing method for polishing an object having a copper film on the surface to be polished, comprising the steps of:

interposing an electrolytic solution including a chelating agent between a cathode member and the polished surface,

applying a voltage between the cathode member functioning as a cathode and the polished surface

functioning as an anode to oxidize the surface of the copper film and form a chelate film of an oxidized copper film,

selectively removing a projecting portion of the chelate film corresponding to the shape of the copper film to expose the copper film of the projecting portion at its surface, and

repeating the above chelate film forming step and the chelate film removing step until the projecting portion of the copper film is flattened.

24. A polishing method as set forth in claim 23, wherein

said polished object includes a stack of films comprised of different materials; and

in said chelate film forming step and chelate film removing step, a current flowing from the surface of the polished object to said cathode member through said electrolytic solution is monitored to control the polishing process in response to the magnitude of the current.

25. A method for production of a semiconductor device, comprising the steps of:

forming at least a groove or hole in an insulation film formed on a substrate,

stacking a metal film on said insulation film

so as to bury the groove or hole,

interposing an electrolytic solution between a electrode member and the metal film,

applying a predetermined voltage between the electrode member and the metal film,

removing the surface of the metal film, and

repeating the above step of removing the metal film until the unevenness of the surface of the metal film is reduced.

26. A method for producing a semiconductor device as set forth in claim 25, wherein said insulation film comprises a silicon dioxide film.

27. A method for producing a semiconductor device as set forth in claim 25, wherein said insulation film comprises a silicon nitride film.

28. A method for producing a semiconductor device as set forth in claim 25, wherein said insulation film comprises an insulation film having a dielectric constant less than a silicon dioxide film.

29. A method for producing a semiconductor device as set forth in claim 28, wherein said insulation film having a dielectric constant less than a silicon dioxide film comprises SiF, SiOCH, polyarylether, porous silica, or polyimide.

30. A method for producing a semiconductor device

as set forth in claim 25, wherein

in said step of forming at least a groove or hole in an insulation film, either a groove or a hole is formed and

in said step of stacking a metal film on said insulation film, either the groove or the hole is buried.

31. A method for producing a semiconductor device as set forth in claim 25, wherein

in said step of forming at least a groove or hole in an insulation film, either a groove and a hole in communication with the bottom surface of the groove is formed and

in said step of stacking a metal film on said insulation film, both the groove and the hole communicating with the bottom surface of the groove are buried.

32. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of stacking a metal film on said insulation film, at least one of Al, W, WN, Cu, Au, and Ag or an alloy of the same is stacked by either a chemical vapor-phase growing process or a physical vapor-phase growing process.

33. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of stacking a metal film on said insulation film, at least

one of Cu, Au, and Ag or an alloy of the same is stacked by an electroplating process.

34. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of stacking a metal film on said insulation film, at least one of Co, Ni, CoWP, Cu, Au, and Ag or an alloy of the same is stacked by an electroless plating process.

35. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of interposing an electrolytic solution between said electrode member and said metal film, an electrolytic solution including an electrolyte and an additive is interposed.

36. A method for producing a semiconductor device as set forth in claim 35, wherein said electrolytic solution comprises copper ions.

37. A method for producing a semiconductor device as set forth in claim 35, wherein said electrolytic solution comprises at least a brightener or a chelating agent as said additive.

38. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of applying a predetermined voltage between said electrode member and said metal film, a periodical pulse-like voltage is applied between the electrode member and the

metal film.

39. A method for producing a semiconductor device as set forth in claim 38, wherein said applied periodical pulse-like voltage has a rectangular, sinusoidal, sawtooth wave, or PAM waveform.

40. A method for producing a semiconductor device as set forth in claim 38, wherein in said step of applying a predetermined voltage between said electrode member and said metal film, a periodical pulse-like voltage is applied so that the current flowing through the cathode member and the metal film becomes small near the end of the process of removing the metal film.

41. A method for producing a semiconductor device as set forth in claim 38, wherein in said step of applying a predetermined voltage between said electrode member and said metal film, a periodical pulse-like voltage is applied so that the current flowing through the electrode member and the metal film changes in a step-like manner.

42. A method for producing a semiconductor device as set forth in claim 38, wherein in said step of applying a predetermined voltage between said electrode member and said metal film, a periodical pulse-like voltage is applied so that the current flowing through the electrode member and the metal film rises gradually

at the beginning of the process of removing the metal film.

43. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of removing the surface of the metal film, the metal film is removed by wiping the surface of the metal film.

44. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of wiping the surface of the metal film, the metal film is wiped by a wiping member having an air hole.

45. A method for producing a semiconductor device as set forth in claim 43, wherein in said step of wiping the surface of the metal film, the surface of the metal film is wiped by a wiping member comprising an elastic material.

46. A method for producing a semiconductor device as set forth in claim 25, wherein said step of interposing an electrolytic solution between said electrode member and said metal film further includes a step of adjusting the electrolytic solution to a predetermined temperature.

47. A method for producing a semiconductor device as set forth in claim 46, wherein, in said step of adjusting said electrolytic solution to a predetermined temperature, the temperature of the electrolytic solution

is adjusted below 80 °C.

48. A method for producing a semiconductor device as set forth in claim 25, further comprising a step of forming a barrier film for preventing diffusion of said metal film to said insulation film on the insulation film so as to bury said groove or hole after forming the groove or hole in the insulation film and before stacking the metal film on said insulation film,

wherein said metal film is stacked on the barrier film in the step of stacking the metal film on said insulation film.

49. A method for producing a semiconductor device as set forth in claim 48, wherein in said step of stacking said barrier film on said insulation film, at least one of Ti, TiN, Ta, TAN, W, WN, Co, CoWP, TiSiN, and NiWP or a stacked structure of the same is stacked.

50. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of removing the surface of said metal film, the step of copper film removal is repeated until the metal film stacked outside said groove or hole is removed.

51. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of applying a predetermined voltage between said electrode member and said metal film and said step of removing the

surface of the metal film, the surface of the metal film is removed in a state of applying a predetermined voltage between the electrode member and the metal film.

52. A method for producing a semiconductor device as set forth in claim 25, wherein in said step of applying a predetermined voltage between said electrode member and said metal film and said step of removing the surface of the metal film, the surface of the metal film is removed after a predetermined time period after applying a predetermined voltage between the electrode member and the metal film.

53. A polishing apparatus for polishing an object having a copper film on the surface to be polished, comprising:

a polishing tool having a polishing surface and having conductivity,

a polishing tool rotating and holding means for rotating the polishing tool about a predetermined axis of rotation and holding the same,

a rotating and holding means for holding a polishing object and rotating the same about a predetermined axis of rotation,

a moving and positioning means for moving and positioning the polishing tool to a target position in a direction facing the polishing object,

a relative moving means for making the polished surface of the polishing object and the polishing surface of the polishing tool relatively move along a predetermined plane,

an electrolytic solution feeding means for feeding an electrolytic solution comprising a chelating agent onto the polished surface, and

a current supplying means for supplying an electrolytic current flowing through the polishing tool through the electrolytic solution from the polished surface by using the polished surface and the polishing tool.

54. A polishing apparatus as set forth in claim 53, wherein said electrolytic current supplying means comprises:

an anode member arranged to be able to be brought into contact or proximity with the polished surface and supply current to the polished surface using the polished surface as an anode and

a power supply for supplying a predetermined voltage between the anode member and polishing tool.

55. A polishing apparatus as set forth in claim 54, wherein said power supply outputs a pulse-like voltage of a predetermined period.

56. A polishing apparatus as set forth in claim 54,

wherein

said polishing tool has an annular shape and one annular end face thereof forms a polishing surface; and

said anode member is provided at the inside of the annular polishing tool not contacting with the same, is held by said rotation and holding means, and is rotated along with the polishing tool.

57. A polishing apparatus as set forth in claim 56, further comprising a cleaning member having a surface for cleaning the polished surface of said anode member provided on the side facing the polished surface of said anode member,

wherein the cleaning member is made of a material able to absorb and pass said electrolytic solution and supplies the electrolytic solution from the anode member to the polished surface.

58. A polishing apparatus as set forth in claim 53, wherein said polishing tool is held by a conductive cathode member connected with said rotation and holding means and is supplied with current through a conductive brush contacting said rotating conductive cathode member.

59. A polishing apparatus as set forth in claim 53, wherein said polished surface comprises a metal more precious than copper formed on the polished surface.

60. A polishing apparatus as set forth in claim 53, further comprising:

a current detecting means for detecting a value of a current flowing from said polished surface to said polishing tool and

a control means for controlling a position of the polishing tool in a direction substantially perpendicular with the polished surface so that the value of the current becomes constant on the basis of a detection signal from the current detecting means.

61. A polishing apparatus which comprises a polishing tool having a polishing surface in contact with the entire surface of the polished surface of the polishing object while rotating and which brings said polishing object into contact with said polished surface while rotating it so as to flatten and polish the same, said polishing apparatus comprising:

an electrolytic solution feeding means for feeding an electrolytic solution comprising a chelating agent onto said polishing surface and

an anode and a cathode capable of supplying electric power in said polishing surface and

flattening and polishing the polished surface by electrolytic composite polishing which combines electrolytic polishing by said electrolytic solution and

mechanical polishing by said polishing surface.

62. A polishing apparatus for polishing an object having a copper film on the surface to be polished, comprising:

a holding means for holding the polished object;

an electrode plate arranged parallel with the polished surface;

a vibration applying means for applying vibration on the polished object;

an electrolytic solution feeding means for feeding an electrolytic solution including a chelating agent between the polished surface and the electrode plate; and

an electrolytic current supplying means for supplying an electrolytic current flowing through said electrolytic solution from said polished surface to the electrode plate.

63. A polishing apparatus for polishing an object having a copper film on the surface to be polished, comprising:

a holding means for holding the polished object;

an electrode plate arranged parallel with the polished surface;

an electrolytic solution feeding means for feeding an electrolytic solution including a chelating agent between the polished surface and the electrode plate;

an electrolytic current supplying means for supplying an electrolytic current flowing through said electrolytic solution from said polished surface to the electrode plate; and

a flushing means for flushing the electrolytic solution between the polished surface and the electrode plate.

64. A polishing apparatus for polishing an object having a metal film on the surface to be polished, comprising:

a holding means for holding the polished object;

a wiper for wiping the surface of the polished object;

an electrolytic solution feeding means for feeding an electrolytic solution on the surface of the polished object;

a facing electrode arranged at a position facing the surface of the polished object; and

a current supplying means for supplying a current between the surface of the polished object and

the facing electrode.

65. A polishing apparatus as set forth in claim 64, wherein said metal film comprises an interconnection metal film.

66. A polishing apparatus as set forth in claim 65, wherein said metal film comprises at least one of copper, aluminum, tungsten, gold, and silver, or an alloy of them, or an oxide or nitride of any of them.

67. A polishing apparatus as set forth in claim 64, wherein said wiper is made of an elastic material.

68. A polishing apparatus as set forth in claim 64, wherein said wiper is provided with an air hole.

69. A polishing apparatus as set forth in claim 64, wherein said electrolytic solution feeding means feeds an electrolytic solution so that the electrolytic solution is contained on the surface of the polished object.

70. A polishing apparatus as set forth in claim 64, wherein said electrolytic solution feeding means has a seepage member made of a material capable of allowing an electrolytic solution to seep out at the end thereof and feeds an electrolytic solution onto the surface of the polished object through the seepage member.

71. A polishing apparatus as set forth in claim 64, further comprising a tank formed so as to surround the periphery of said polished object and for containing the

electrolytic solution fed by said electrolytic solution feeding means.

72. A polishing apparatus as set forth in claim 64, wherein said electrolytic solution feeding means feeds an electrolytic solution comprising an electrolyte and an additive.

73. A polishing apparatus as set forth in claim 72, wherein said additive having at least one of a brightener, a chelating agent, and copper ions.

74. A polishing apparatus as set forth in claim 72, wherein said electrolytic solution having a polishing abrasive.

75. A polishing apparatus as set forth in claim 64, wherein said facing electrode comprises a metal material at least as precious as the metal film on the surface on the polishing object.

76. A polishing apparatus as set forth in claim 64, wherein said facing electrode comprises an air hole.

77. A polishing apparatus as set forth in claim 64, wherein said facing electrode can be driven to rotate.

78. A polishing apparatus as set forth in claim 64, wherein said facing electrode is divided into several regions.

79. A polishing apparatus as set forth in claim 64, further comprising a contact electrode for guiding a

current form said current supplying means to a metal film on the surface of the polishing object.

80. A polishing apparatus as set forth in claim 64, further comprising an electrode able to be brought into proximity of the surface of said polished object and for guiding a current form said current supplying means to a metal film on the surface of the polishing object.

81. A polishing apparatus as set forth in claim 64, wherein said current supplying means supplies a current by applying a periodical pulse-like voltage between the surface of said polished object and said facing electrode.

82. A polishing apparatus as set forth in claim 81, wherein said current supplying means supplies a current by applying a periodical pulse-like voltage having a rectangular, sinusoidal, sawtooth, or PAM waveform between the surface of said polished object and said facing electrode.

83. A polishing apparatus as set forth in claim 64, wherein said current supplying means is able to change a current flowing between the surface of said polished object and said facing electrode at least at the beginning and end of the polishing.

84. A polishing apparatus as set forth in claim 64, further comprising a temperature adjusting means for

adjusting the temperature of the electrolytic solution fed by said electrolytic solution feeding means.

85. A polishing apparatus as set forth in claim 84, wherein said temperature adjusting means adjusts the temperature of the electrolytic solution to below 80°C.

86. A polishing apparatus for polishing an object having a metal film on the surface to be polished, comprising:

a holding means for holding the polished object;

a wiper for wiping the surface of the polished object;

a relative moving means for relatively moving the surface of the polishing object and the wiper;

an electrolytic solution feeding means for feeding an electrolytic solution on the surface of the polished object;

a facing electrode arranged at a position facing the surface of the polished object; and

a current supplying means for supplying a current between the surface of the polished object and the facing electrode.

87. A polishing apparatus as set forth in claim 86, wherein said metal film is an interconnection metal film.

88. A polishing apparatus as set forth in claim 87,

wherein said metal film comprises at least one of copper, aluminum, tungsten, gold, and silver, or an alloy of them, or an oxide or nitride of any of them.

89. A polishing apparatus as set forth in claim 86, wherein said relative moving means presses said wiper on the surface of said polished object and rotates the wiper relative to a predetermined center axis of rotation.

90. A polishing apparatus as set forth in claim 86, wherein said relative moving means presses said wiper against the surface of said polished object and horizontally moves the wiper on the surface of said polished object.

91. A polishing apparatus as set forth in claim 86, wherein said relative moving means rotates said holding means relative to a predetermined center axis of rotation.

92. A polishing apparatus as set forth in claim 86, wherein said relative moving means horizontally moves said holding means in a surface parallel with the surface of said wiper.

93. A polishing apparatus as set forth in claim 86, wherein said wiper is made of an elastic material.

94. A polishing apparatus as set forth in claim 86, wherein said wiper is provided with an air hole.

95. A polishing apparatus as set forth in claim 86,

wherein said electrolytic solution feeding means feeds an electrolytic solution so that the electrolytic solution is contained on the surface of the polished object.

96. A polishing apparatus as set forth in claim 86, wherein said electrolytic solution feeding means has a seepage member made of a material capable of allowing an electrolytic solution to seep out at the end thereof and feeds an electrolytic solution onto the surface of the polished object through the seepage member.

97. A polishing apparatus as set forth in claim 86, further comprising a tank formed so as to surround the periphery of said polished object and for containing the electrolytic solution fed by said electrolytic solution feeding means.

98. A polishing apparatus as set forth in claim 86, wherein said electrolytic solution feeding means feeds an electrolytic solution including an electrolyte and an additive.

99. A polishing apparatus as set forth in claim 98, wherein said additive having at least one of a brightener, a chelating agent, and copper ions.

100. A polishing apparatus as set forth in claim 98, wherein said electrolytic solution having a polishing abrasive.

101. A polishing apparatus as set forth in claim 86,

wherein said facing electrode comprises a metal material at least as precious as the metal film on the surface on the polishing object.

102. A polishing apparatus as set forth in claim 86, wherein said facing electrode comprises an air hole.

103. A polishing apparatus as set forth in claim 86, wherein said facing electrode can be driven to rotate.

104. A polishing apparatus as set forth in claim 86, wherein said facing electrode is divided into several regions.

105. A polishing apparatus as set forth in claim 86, further comprising a contact electrode for guiding a current form said current supplying means to a metal film on the surface of the polishing object.

106. A polishing apparatus as set forth in claim 86, further comprising an electrode able to be brought into proximity with the surface of said polished object and for guiding a current form said current supplying means to a metal film on the surface of the polishing object.

107. A polishing apparatus as set forth in claim 86, wherein said current supplying means supplies a current by applying a periodical pulse-like voltage between the surface of said polished object and said facing electrode.

108. A polishing apparatus as set forth in claim

107, wherein said current supplying means supplies a current by applying a periodical pulse-like voltage having a rectangular, sinusoidal, sawtooth, or PAM waveform between the surface of said polished object and said facing electrode.

109. A polishing apparatus as set forth in claim 86, wherein said current supplying means is able to change a current flowing between the surface of said polished object and said facing electrode at least at the beginning and end of polishing.

110. A polishing apparatus as set forth in claim 86, further comprising a temperature adjusting means for adjusting the temperature of the electrolytic solution fed by said electrolytic solution feeding means.

111. A polishing apparatus as set forth in claim 110, wherein said temperature adjusting means adjusts the temperature of the electrolytic solution to below 80°C.